



Leaf Assemblages from the Early Miocene Lignite Opencast Mine Oberdorf (N Voitsberg, Styria, Austria)

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1 Table and 1 Plate

Styria
Pannonian Basin
Styrian Basin
Lignite
Early Miocene
Leaves
Cuticles

Österreichische Karte 1 : 50.000
Blatt 163

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Blätter-Vergesellschaftungen aus dem Braunkohlentagebau Oberdorf (N Voitsberg, Steiermark, Österreich)

Zusammenfassung

Die kohleführende Abfolge des Tagebaus Oberdorf, N Voitsberg, Steiermark, Österreich (Unter-Miozän) ist reich an pflanzenführenden Horizonten. Die fossilen Blätter-Vergesellschaftungen sind Gegenstand dieser Studie. Die botanisch-systematische Bestimmung der Blattreste erfolgte nach großmorphologischen und kutikularanalytischen Untersuchungen. Entsprechend den Unterschieden in der floristischen Zusammensetzung der zahlreichen Gesellschaften lassen sich vier Abschnitte differenzieren. Die Unterschiede reflektieren fazielle Veränderungen im Gebiet des fluviatil-lakustrischen Systems um Oberdorf zur Zeit der Beckenfüllung.

Abstract

The leaf assemblages of the lignite deposits of the opencast mine Oberdorf, N Voitsberg, Styria, Austria (Early Miocene) are investigated. The botanical determinations are based on morphological and cuticular analyses. The floristic compositions in the different levels vary considerably so that roughly four sections can be distinguished. These differences are interpreted to be more likely a result of changing environment in the Oberdorf region during the depositional phase than to reflect climatic ones.

1. Introduction

The lignite-bearing sequence of the opencast mine Oberdorf is rich in assemblages of fossil leaves. In many cases these are associated with other plant organs (mainly diaspores) as well. Using the opportunity of joint multi-

disciplinary investigations the samples were studied for all plant remains preserved (MELLER and ZETTER, this volume).

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2. Taphonomy and Preservation

The grain size of the leaf-bearing sediments varies from clays, silty clays, clayey, marly silts, sandy silts to silty sands (the coal itself largely lacks determinable leaf remains). Of course, the preservational state and the species composition is influenced by the sediment type. Generally, in finer grained clastics the leaf laminae, preserved as carbonaceous compressions, are less heavily fragmented than in coarser sediments. This results from lesser mechanical strain due to transport and water energy. Leaf assemblages in finer grained clastics are therefore regarded to have been deposited almost autochthonously, while those in coarser sediments are interpreted to bear a higher allochthonous impact (see below). Nevertheless, the cuticular membranes of the leaves may be very well or sometimes even better preserved in silty/sandy facies than in clayey/silty ones.

One feature common to all the investigated samples is the low number of species (mostly <10 leaf taxa). In many samples fusain fragments have been observed.

3. Methodology

Samples were taken from all levels that were found to bear leaf remains. From some layers several samples were collected to obtain a better insight into the lateral variations in the taxas' composition. Generally the material was split first, but layers with tightly packed leaves were washed as well and the leaf fragments transferred on slides. Cuticles were investigated from almost entire leaves down to small leaf fragments that were obtained by washing and sieving the diaspora samples. The applied cuticle preparation technique has been described in KOVAR-EDER (1996). Some collected samples remain to be investigated.

4. The Floristic Composition of the Leaf Assemblages

In the whole lignite-bearing sequence roughly four different sections of leaf-bearing sediments can be distinguished so far:

The generally poorly sorted silty/sandy layers with components of pebble size from the top of the footwall and the base of the main seam; lignitic (silty) clays intercalated in the main seam; the (silty) sandy main seam parting in the western subbasin; the (clayey, marly) silts in the hanging wall in the eastern subbasin. The differences include not only the sediment type but also affect the species composition in these different sections.

Assemblages from the Top of the Footwall and the Base of the Main Seam

Although the leaf remains are mostly heavily fragmented (mainly <1 cm²), these samples are more species rich than all the other samples investigated. In addition, these were the only assemblages that contained several evergreen species that more likely constitute mesophytic (zonal) forest components than wetland (azonal) elements: *Tetraclinis salicornioides* (UNGER 1841) KVACEK 1989, *Laurophyllum pseudoprinceps* WEYLAND & KILPPER 1963, *L. pseudovillense* KVACEK 1971, *L. markvarticense* KVACEK 1971, *Trigonobalanopsis rhamnoides* (ROSSMÄSSLER 1840) KVACEK & WALTHER 1988, "*Castanopsis*" *bavarica* KNOBLOCH & KVACEK 1976. Some of them have previously been described only from very few

other European localities. Moreover, these species represent elements characteristic of "Younger Mastixioid assemblages". These results correspond with the diaspora spectrum (see MELLER, this volume). The other taxa determined in these samples represent true elements of different habitats within the fluvial/lacustrine environment or may have occurred in mesophytic forests as well: *Sequoia abietina* (BRONGNIART 1822) KNOBLOCH 1964 and/vel *Glyptostrobus europaeus* (BRONGNIART 1833) UNGER 1850, *Quercus rhenana* (KRÄUSEL & WEYLAND 1950) KNOBLOCH & KVACEK 1976, *Daphnogene polymorpha* (A. BRAUN 1845) ETTINGSHAUSEN 1851, *Myrica* sp., *Fraxinus* sp. *Viscum* sp. (KOVAR-EDER et al., in press a; MELLER et al., in press).

Assemblages from Lignitic Silty/Clayey Partings in the Main Seam

In the western and the eastern subbasin, lignitic (silty) clays variable in thickness are frequently intercalated in the main seam. These dirt bands sometimes bear leaf remains densely packed together with only slightly fragmented laminae. *Quercus rhenana* is the monodominant element here, associated usually with *Glyptostrobus europaeus*, occasionally with *Myrica joannis* ETTINGSHAUSEN 1858 emend. KOVAR-EDER 1996, and *Fraxinus ungeri* (GAUDIN in GAUDIN & STROZZI 1859) KNOBLOCH & KVACEK 1976. This very characteristic type of assemblage has already been described from other Central European lignite deposits (e.g. Zittawa Basin, Czech Republic, Poland) and is understood as the remains of a successional stage within the lignite-forming vegetation (KVACEK & BUZEK, 1983; KOVAR-EDER, 1996).

Assemblages from the Sandy (Silty) Main Seam Parting in the Western Subbasin

In the western subbasin, the seam towards the west is divided into a lower and an upper seam by a sandy, silty seam parting of up to 45 m thickness. This part of the sequence includes numerous plant-bearing layers sometimes only a few cm thick. Cross-bedding structures have been observed there along with the accumulation of plant detritus on bedding planes which indicates flooding events. In this strongly fluvial influenced section, the species spectrum is extremely poor again; some layers contain only one or two taxa, but these are rich in specimens (e.g. *Salix* or *Sequoia*). These assemblages include: *Sequoia abietina*, *Cephalotaxus* ? *europaea* MAI 1987, *Salix varians* GÖPPERT 1855, *Cercidiphyllum crenatum* (UNGER 1850) R.W. BROWN 1935, *Myrica joannis* ETTINGSHAUSEN 1858 emend. KOVAR-EDER 1996, ? *Gordonia* (KOVAR-EDER & MELLER, in press).

Assemblages from (Clayey) Silts in the Hanging Wall of the Eastern Subbasin

In the eastern subbasin, parts of the hanging wall may be regarded as floodplain sediments which bear numerous fossiliferous levels rich in leaf remains. The leaf laminae are only slightly fragmented, and almost entire leaves are occasionally present. The co-occurrence of leaves and fruits of *Cercidiphyllum* and *Fraxinus* and twigs of *Cercidiphyllum* should be emphasized. The latter findings bear short shoots (Pl. 1: Fig. 25), which are described in detail in KOVAR-EDER et al. (in press b). This section of the lignite-bearing sequence is still under investigation, so that the list of taxa may be regarded as being tentative: Polyodiaceae, *Glyptostrobus europaeus* and/vel *Sequoia abietina*, *Cercidiphyllum crenatum*, *Fraxinus* sp., *Alnus* sp., *Salix* sp., *Acer tricuspidatum* BRONN 1838 sensu WALTHER 1972, *Zelkova zelkovifolia* (UNGER 1843) BUZEK & KOTLABA in KOTLABA, 1963.

Table 1
Number of investigated leaf samples and main taxa distribution.
*** = dominant; ** = present in more than one sample and mostly represented by more than 5 specimens; * = present.

Number of investigated leaf samples and main taxa distribution				
	basal layers western and eastern subbasin	lignitic clays western and eastern subbasin	sandy seam parting western subbasin	hanging wall eastern subbasin
nr. of samples investigated	7	7	6	7
nr. of specimens	> 300	> 600	> 200	500-1000
nr. of cuticles investigated	> 200	117	31	194
<i>Tetraclinis salicornioides</i>	** (1 sample)			* (1 sample)
<i>Daphnogene polymorpha</i>	**			
<i>Laurophyllum pseudoprinceps</i>	**			
<i>Laurophyllum markvarticense</i>	**			
<i>Laurophyllum pseudovillense</i>	*			
<i>Trigonobalanopsis rhamnoides</i>	**			
„ <i>Castanopsis</i> “ <i>bavarica</i>	*			
<i>Quercus rhenana</i>	*	***	*	
<i>Myrica joannis</i>		*		
<i>Fraxinus ungeri</i>		*		
<i>Glyptostrobus europaeus</i>	* ?	**(*)	* ?	** ?
<i>Sequoia abietina</i>	**		**	**
<i>Cephalotaxus ? europaea</i>			*(*)	
<i>Cercidiphyllum crenatum</i>			*	*** (1 sample)
<i>Salix</i> sp.			**(*)	*
<i>Alnus</i> sp.				***
<i>Acer tricuspidatum</i>				*
<i>Fraxinus</i> sp.				*(*)

The differences in the leaf-species spectra of the four sections described above more likely reflect landscape changes and the development of the wetlands in the fluvial system than climatic changes (HAAS et al., this volume). These differences have also been recognized in the diaspore record, although far less distinctively. This is interpreted to result from different taphonomic processes that led to the deposition of the isolated plant organs. In most of the investigated levels the leaf remains were probably deposited almost autochthonously (well-preserved leaf laminae, different organs such as leaves and fruits of one taxon, fine-grained sediment). Therefore, these leaf assemblages may reflect the species composition of restricted habitats within these wetlands better than other plant organ assemblages. Only the basal layers clearly reflect a stronger allochthonous influence (heavily fragmented leaf laminae and sediment grain size up to pebbles).

5. Features Distinguishing the Oberdorf Leaf Assemblages from those of other Central European Early/Middle Miocene Coal Deposits

The Taxodiaceae are the most characteristic plant family in European Tertiary coal deposits. In Oberdorf, *Glyptostrobus* and *Sequoia* are the main representatives. Either one of them or both are present in almost every sample. On the other hand, the genus *Taxodium* which is a main component of Tertiary swamp forest communities (e.g. North Bohemia: BUZEK et al., 1987; Saxony: MAI & WALTHER, 1991), has not yet been discovered there. This situation in the leaf record is reflected by the diaspore spectrum as well (MELLER, 1995).

No needles of members of the Pinaceae family have been found yet. Within the diaspore record only very poorly preserved cone remains (no seeds) have been described; they have been assigned to the Pinaceae, but not to the generic level (MELLER, 1995: 37). We therefore lack any indication of a pine-rich pioneer vegetation on sandy

soils such as is documented commonly from other localities (e.g.: BUZEK et al., 1987, p. 152: North-Bohemian Basin, p. 154: Cheb Basin; BUZEK et al., 1992, p. 131: North-Bohemian Basin).

A striking fact is the almost complete lack of waterplants and waterplant associations as well as of herbaceous monocotyledons (type Sparganiaceae/Typhaceae/Cyperaceae/Poaceae/Zingiberaceae) in the leaf record. In the diaspore assemblages these groups show a low diversity and typically occur in low percentages (MELLER, 1995 and this volume). Although the spectrum of dicotyledons resembles the North Bohemian results, the remarkable scarcity of monocotyledons is in strong contrast to the lignite deposits of North Bohemia and Saxony. Therefore, there is only little evidence for extensive herbaceous wetland habitats (reed facies).

6. The Leaf Spectrum Compared to the Diaspore Record

Comparing both organ assemblages from the lignite-bearing sequence in Oberdorf reveals taxa that represent important elements in both spectra such as *Glyptostrobus europaeus* and *Sequoia abietina*. The family Taxodiaceae is present in the pollen record as well. On the other hand, important constituents in one organ spectrum may be rare or missing entirely in the other: The fruits of *Quercus rhenana*, the monodominant leaf species in some lignitic clays, remain unknown. The Lauraceae are regarded as being an essential family, mainly in mesophytic forests. They are best represented (seven species) in the leaf record. *Magno-*

lia and *Nyssa* are very abundant in the diaspore assemblages. They are also considered to be important tree species of mainly swampy and fluviatile environment. *Magnolia* has been discovered in one of the numerous investigated leaf samples and *Nyssa* has been identified so far by one leaf only. The joint investigations of all the plant remains, clearly allow a more detailed picture of the vegetational pattern in the Oberdorf area during the depositional period to be reconstructed.

Acknowledgements

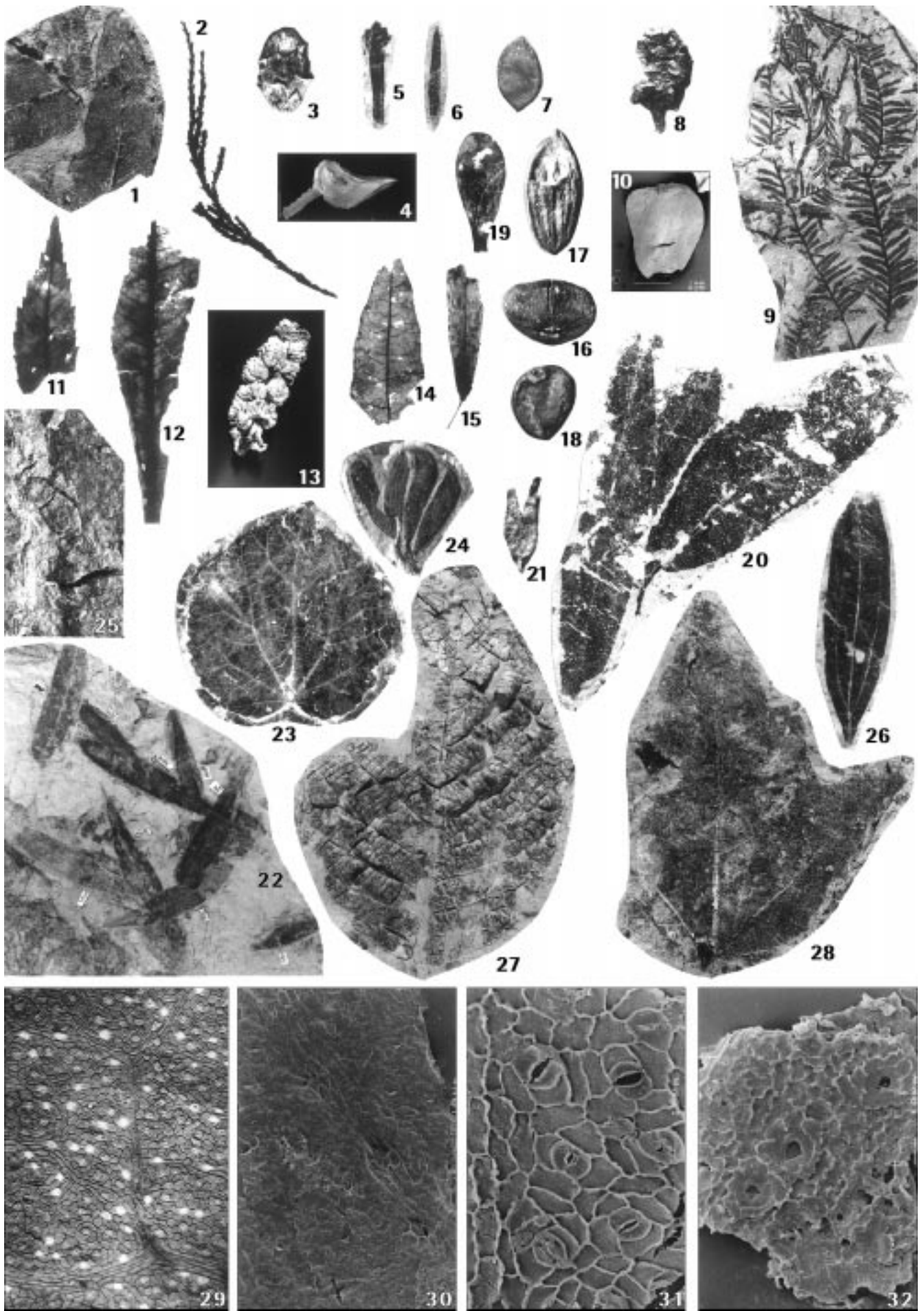
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Plate 1

- Fig. 1: *Osmunda parschlugiana* (UNGER 1847) ANDREANSZKY 1959. Fragment of a fern leaflet. 1996B0075/0008; 1×.
- Fig. 2: *Glyptostrobus europaeus* (BRONGNIART 1833) UNGER 1850. Branched twig with needles. 1995/0060/0208; 1×.
- Fig. 3: *Glyptostrobus europaeus* (BRONGNIART 1833) UNGER 1850. Cone. 1992/0380/0001; 1×.
- Fig. 4: *Glyptostrobus europaeus* (BRONGNIART 1833) UNGER 1850. Seed. SEM, 1992/0387/0002; 5×.
- Fig. 5: *Tetraclinis salicornioides* (UNGER 1847), KVACEK 1986. Twig segment. 1997B0022/0001; 1×.
- Fig. 6: *Cephalotaxus ? europaea* MAI 1987. Isolated needle. 1996B0071/0002; 1×.
- Fig. 7: *Cephalotaxus miocenica* (KRAUSEL 1920) GREGOR 1979. Seed. 1992/0383/0001; 1×.
- Fig. 8: *Sequoia abietina* (BRONGNIART 1822) KNOBLOCH 1964. Cone. 1990/0158/0002; 1×.
- Fig. 9: *Sequoia abietina* (BRONGNIART 1822) KNOBLOCH 1964. Branched twig with needles. 1983/0047/0013; 0,5×.
- Fig. 10: *Sequoia abietina* (BRONGNIART 1822) KNOBLOCH 1964. Seed. SEM, 1992/0387/0027; 7×.
- Fig. 11: *Myrica joannis* ETTINGSHAUSEN 1858 emend. KOVAR-EDER. 1995/0060/0266; 1×.
- Fig. 12: *Myrica joannis* ETTINGSHAUSEN 1858 emend. KOVAR-EDER. 1995/0060/0441; 1×.
- Fig. 13: *Myrica* sp. Male flower. 4×.
- Fig. 14: *Fraxinus ungeri* (GAUDIN in GAUDIN & STROZZI 1859). KNOBLOCH & KVACEK 1976. 1995/0060/0214; 1×.
- Fig. 15: *Fraxinus* sp. Winged fruit. 1995/0044/0016; 1×.
- Fig. 16: *Carya ventricosa* (STERNBERG 1825) UNGER 1861. Nut. 1992/0269/0005; 1×.
- Fig. 17: *Nyssa ornithobroma* UNGER 1861. 1992/0315/0005; 2×.
- Fig. 18: *Magnolia bursaracea* (MENZEL 1913) MAI 1975. 1992/0392/0003; 2×.
- Fig. 19: *Viscum morlotii* (UNGER 1852) KNOBLOCH & KVACEK 1976. Leaf. 1995/0044/0014; 1×.
- Fig. 20: *Salix varians* GÖPPERT 1855. Leaves tightly packed together. 1996B0070/0029; 1×.
- Fig. 21: *Salix* sp. Open fruiting capsule. 1992/0273/0004; 2×.
- Fig. 22: *Quercus rhenana* (KRAUSEL & WEYLAND 1950) KNOBLOCH & KVACEK 1976. Numerous, almost entire leaves tightly packed together in a clayey silt. 1996B0072/0070-0081; 0,2×.
- Fig. 23: *Cercidiphyllum crenatum* (UNGER 1850) R.W. BROWN 1935. Leaf. 1995/0044/0001; 1×.
- Fig. 24: *Cercidiphyllum crenatum* (UNGER 1850) R.W. BROWN 1935. Fruit. 1983/0047/0007; 1×.
- Fig. 25: *Cercidiphyllum*. Twig fragment bearing a characteristic shortshoot. 1997B0021/0001; 2×.
- Fig. 26: *Daphnogene polymorpha* (A. BRAUN 1845) ETTINGSHAUSEN 1851. 1995/0030/0029.
- Fig. 27: *Alnus* sp. 1991/0162/0015G; 1×.
- Fig. 28: *Acer tricuspidatum* BRONN sensu WALTHER 1972. 1991/0162/0015A; 1×.
- Fig. 29: *Laurophyllum markvarticense* KVACEK 1971. Cuticle of the lower epidermis. 1995/0058/0020/1, interference-contrast; 200×.
- Fig. 30: *Laurophyllum pseudovillense* KVACEK 1971. Cuticle of the lower epidermis, inner surface. 1995/0058/0014B, SEM; 200×.
- Fig. 31: *Daphnogene polymorpha* (A. BRAUN 1845) ETTINGSHAUSEN 1851. Cuticle of the lower epidermis, inner surface. 1995/0030/0001, SEM; 400×.
- Fig. 32: *Trigonobalanopsis rhamnoides* (ROSSMÄSSLER 1840) KVACEK & WALTHER 1988. Cuticle of the lower epidermis, inner surface. 1995/0058/0003B, SEM; 500×.

The diaspore figures have been provided by B. MELLER.

SEM: scanning electron microscope.



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